

Do the Socioeconomic Systems Require Further Generalization of Current Physical Models

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ABSTRACT

Dynamics enters to Socioeconomic systems in a way which has no analog in the present day natural science. In this paper socioeconomic systems are discussed as a further generalization of existing models of natural sciences.

Keywords: Sociophysics, Socio dynamics.

1. INTRODUCTION

Many people wonder how theories aimed at explaining the physical world could be applied to understand complex structures, such as those found in the social and economic behavior of human beings. However there have been attempts by Physicists to apply their ideas and tools to an area that seems a long way from traditional physics-called Sociophysics and Econophysics¹⁻⁶. Natural science and social sciences seem to belong to the distinct categories of natural (or hard) science and social (or soft) science. Physics as a natural science is supposed to be precise or specific whose predictive powers are based on the use of a few but universal properties of matter that are sufficient to explain many physical phenomena. However there are areas of physics that are not so hard in that they are not able to be tested experimentally.

At the one hand, any phenomena in astrophysics can never be performed experimentally, on the other hand increasingly one finds the use of experiments in Social Sciences, even if these are arguably not as controlled or scientific as most experiments in physics, chemistry, or biology.

Economics as a social science deals with how societies efficiently use their resources to produce valuable commodities and distribute them among different people or economic agents. It is a discipline related to almost everything around us, starting from the marketplace through the environment to the fate of nations. At first sight this may seem a very different situation from that of physics, whose birth as a well-defined scientific theory is usually associated with the study of particular mechanical objects moving with negligible friction, such as falling bodies and planets.

However, a deeper comparison shows many more analogies than differences. On a general level, both economics and physics deal with 'everything around us', but from different perspectives. On a practical level, the goals of both disciplines can be either purely theoretical in nature or strongly oriented towards the improvement of the quality of life. On a more technical side, analogies often become equivalences.

One way to relate them is in terms of what parts of the universe they study within the great hierarchy of the structure of reality. Physics deals with the two greatest extremes: nuclear physics at the sub-atomic particle level, and astrophysics at the cosmic and universal level. As one moves up the hierarchy from nuclear physics through greater levels of aggregation one moves through realms studied respectively by chemistry, molecular biology, organic biology, psychology, economics, political science and sociology, ecology, climatology and geology, and finally to astrophysics as one moves beyond the scale of the planet earth. In this hierarchy we find the social sciences occupying an intermediate scale, with economics providing a crucial link from the behavior of individual people to the behavior of groups of people.

There is also an intellectual hierarchy of the disciplines as well. This generally moves from the more abstract and theoretical to the less so, with pure mathematics at the top, followed by its applied forms (including statistics and computer science), with physics generally coming next, again with the theoretical viewed as above the empirical, then to chemistry (and closely related molecular biology), then on to economics, which has

the most mathematical orientation of the social sciences, on through ecology, psychology, and to political science and sociology, even as these latter disciplines have become more mathematical in some of their branches, especially with the application of game theory.

This implicit intellectual superiority of Natural Science over Social Sciences opens the door to potential conflicts between the two groups.

1.1 Misconception about Physical Laws

There is a common misconception about what a "physical law" is? While comparing physical and socioeconomic laws it is argued that physical laws like Newton's law of Gravitation is universally valid in space and time where socioeconomic equations whatever they mean, describe the system dynamics today, in general, will no longer will be true tomorrow. However this discrimination also is not true. While describing Newton's laws of Gravitation, evolutionary aspect of the system (universe) is not taken into account. If we believe in an evolutionary perspective for the origin and history of the universe, there might have been a time when Newton's law was not valid and even meaningless. Similarly socioeconomic systems like civilizations, economies or stock markets are systems that are always in evolution. Thus there is no quantitative difference between a market description and Newton's law in this respect. The only difference is of evolutionary time scale. Before stock market came into existence, any description was meaningless. Now the stock markets are there, there may also exist a reasonably good quantitative description of market dynamics where non-

stationarities and memories are more important than elsewhere.

1.2 Models for Socioeconomic Systems

Many Phenomena in nature are far too complex to analyze directly. Solving equations for the motion of all the atoms in a block of ice, or the boulders in an earthquake fault, or the nodes on the Internet or modeling the behavior of each individual in a mob is simply infeasible. Almost all real systems exhibit nonlinearities to some extent. For such systems a small change in a parameter can lead to sudden and dramatic changes in both the qualitative and quantitative behavior of the system. A linear system has only one equilibrium point, and if that point becomes unstable, the system collapses. However this is not necessarily true with nonlinear systems. Being one point unstable, the system may lead towards another point as there are many possible equilibrium points. Socioeconomic systems are evolving nonlinear systems which have multiple equilibria changing with time.

Despite this, such systems often show simple, striking behavior. Statistical mechanics and Nonlinear Dynamics can be used to explain the simple behavior of complex systems. Statistical mechanics and nonlinear dynamics bring together concepts and methods that infiltrate into many fields of science, engineering, and mathematics and even finance and other socioeconomic systems. Ensembles, entropy, phases, emergent laws, chaos, bifurcations, etc. are concepts and methods rooted in the physics but also have become important in biology, computer science, chemistry and social sciences like finance and demography. In

turn, these broader applications bring perspective and insight to Natural science also.

In this interdisciplinary approach Physics as a natural science provides insightful tool for the study of socioeconomic systems, now the question is can physics also be benefitted from it? The answer is “probably yes”. If natural science and natural scientists are playing a vital role in the development of social sciences, social science and social scientists also have shown their impact on the development of natural science.

If there are many standard models of economics which came from physics, there are also models of natural sciences which have its roots in social sciences. Vilfredo Pareto was an economist and sociologist, even as he preceded the physicists in studying distributions exhibiting scaling laws. Bachelier developed the theory of Brownian motion five years before Einstein did in order to model financial markets⁷. This approach could be used for the pricing of options and derivatives in financial markets. Bachelier was a mathematician who studied financial markets, but developed the idea of Brownian motion before the physicists got to it.

There are many socioeconomic systems whose mathematical models have no direct analog in natural sciences. Dynamics of such systems requires something more than that is applied in traditional Physics approaches. There is still no method to quantify an individual human sentiment.

But there is a fundamental question that how socioeconomic systems are different than a physical system? Physical

systems like planets or stars, weather or molecules etc. do not care what scientists think about them. Social systems, on the other hand, consists of objects that read news papers, books and journals, watch T.V., access internet and change their behavior as a result. Kepler's model of planetary motion did not affect Saturn's course but any model of stock price pattern will not work at all if it is known to all rendering the model totally obsolete. Similarly many viruses are known to biologists who change their structure when a human body is medicated.

Interacting units in socioeconomic are intelligent agents with adaptive strategies and not mindless particles obeying simple microscopic laws. The effort to understand the system changes the system itself, indicating that such systems possess more complexity than a physical system. Econophysics applications to socioeconomic systems can be viewed as attempts to quantify collective behavior of human sentiment in terms of Rational Expectations, adaptive behavior, market bubbles and crashes etc. Statistical physics and nonlinear dynamics provide an expertise to deal with a complex system with large number of agents interacting nonlinearly with each other. For example a stock market can be viewed as a generalized model of a gas in which each molecule is an intelligent one and behaves differently in similar environment with different choices.

There is another difference between the dynamics of the two types of systems. There are many socioeconomic systems whose mathematical models have no direct analog in natural sciences. Dynamics of such systems requires something more than that is

applied in traditional Physics approaches.

Dynamics enters the socioeconomic models in two quite different and fundamental ways:

Models with past lag: In this type of models the present state of the system depends on the past history of the system. Such models are typically of the form:

$$y_t = f(y_{t-1}, y_{t-2} \dots \dots \dots y_{t-n}, \dots \dots \dots) \quad (1)$$

Such models are common in natural sciences. Here we have considered just a one period lag. The model can be generalized for many period lags.

Models with future lag: In such type of models the present state of the system depends on the future expected state of the system. Taking a one period future lag and denoting the present expectation about the variable y one period from now by Ey_{t+1} , such models are expressed in the form:

$$y_t = f(Ey_{t+1}, Ey_{t+2} \dots \dots \dots Ey_{t+n}, \dots \dots \dots) \quad (2)$$

Agents of a socioeconomic system in the present state have expectations (or beliefs) about the future. Price of a share depends on the expected performance of the company or market in future. This model has no counterpart in natural science. The natural science provides the mathematics for handling past lags but has nothing to say about future lags. There is certainly no reason to suppose modeling past lags is the same as modeling future lags. Furthermore, a given model can incorporate both past lags and future lags and can be modeled by

$$y_t = f(y_{t-1}, y_{t-2}, \dots, y_{t-n}, \dots, Ey_{t+1}, Ey_{t+2} \dots Ey_{t+n}, \dots) \quad (3)$$

The future lag model gained most attention in the 1970s, most especially with the rise in rational expectation models. Once a future lag enters a model it becomes absolutely essential to model expectations, and at the present time there is no generally accepted way of doing this. It means that at the present there are a variety of ways of modeling expectations, each with its strengths and weaknesses. This is an area for future research. Thus, since economic systems can be modeled in an abstract or mathematical form and since tools of physics can be applied to economics, both economics and physics can be benefitted from such exploration. Physics provides effective tools for analysis of socioeconomic phenomena and investigation of socioeconomic systems generalize the concepts and the scope of physics.

2. CONCLUSION

It is not unlikely that the ideas developed by Social Science will influence physics and other branches of natural science. The complicated nature of the interplay between Social Science and natural science that has transpired in the past seems very likely to be a model for the future. This complicated interplay replicates a broader pattern of developments as various disciplines are influencing each other

through complexity theory and other multi or transdisciplinary ideas.

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